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Epitaxial Magnetic Metal/Semiconductor Heterostructure Interfaces

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The spin-dependent transport across ferromagnet/semiconductor interfaces depends critically on their structure and electronic properties. Interfacial reactions, the formation of nonmagnetic interlayers, and conductivity mismatch have been attributed to a low efficiency of spin injection. A range of ferromagnetic elemental and metallic compound/compound semiconductor tunneling contacts for spin injection have been developed. The contacts have been characterized by a variety of methods: *In situ* methods included scanning tunneling microscopy (STEM), X-ray photo-electron spectroscopy (XPS), reflection high-energy electron diffraction (RHEED), and low-energy electron diffraction (LEED); *ex situ* methods included X-ray diffraction (XRD), Rutherford backscattering spectrometry (RBS), high angle annular dark field STEM (STEM-HAADF), magnetotransport, and magnetic characterization combined with molecular beam expitaxy (MBE) growth.

In the case of Fe_3Ga/GaAs(001) interfaces, the interface reconstruction was found to depend on the GaAs(001) surface reconstruction and the Fe_3Ga growth conditions. The efficiency of the spin-polarized current injected from the ferromagnetic contact has been determined by measuring the electroluminescence polarization of the light emitted from $Ga_{1-x}Al_xAs$ light-emitting diodes as a function of applied magnetic field and temperature. Interfacial reactions during MBE growth and post-growth anneal, as well as the band structure of the semiconductor device, were found to have a dramatic influence on the measured spin injection, including sign reversal. Lateral spin-transport devices with an epitaxial ferromagnetic metal source and drain tunnel barrier contacts have been fabricated. These devices have allowed demonstration of electrical detection and the bias dependence of spin-polarized electron injection and accumulation at the contacts.

This presentation will emphasize the progress in the understanding of the atomic-scale structure of epitaxial magnetic metal/III-V semiconductor heterostructures interfaces and the influence this structure on the magnetic and spin transport properties.